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(54) **Optical systems**

(57) An achromatic lens system comprising at least two glass lenses, one lens being made of a first glass chosen to have the property known as a shortened blue partial (as hereinbefore defined), a refractive index not greater than 1.70, and a V number less than 55, the glass comprising at least the following components: SiO₂, R₂O and ZrO₂, where R₂O is chosen from Li₂O, Na₂O and K₂O, the said components together forming at least 30% by weight of the glass (the balance consisting of compatible components), and the other lens is made from a second glass with a V number of 50 or more.

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n_f is the refractive index of the glass for the blue hydrogen line F of wavelength 4861 Angstrom units

n_c is the refractive index of the glass for the red hydrogen line c of wavelength 6563 Angstrom units

Since lines d and e are near the middle of the visible spectrum, n_d and/or n_e are often referred to as the mean refractive index.

The partial dispersions of the glass are given by:-

$$n_g - n_e \text{ Blue End}$$

$$n_f - n_d \text{ Blue End}$$

$$n_d - n_c \text{ Red End}$$

Further the mean dispersions of the glass are:-

$$n_f' - n_c'$$

$$n_f - n_c$$

The relative dispersions are as follows:-

$$\frac{n_g - n_e}{n_f' - n_c'} \quad \text{Blue End}$$

$$\frac{n_g - n_e}{n_f - n_c} \quad \text{Blue End}$$

The equation of the partial against V number is

$$P_{xy} = a_{xy} + b_{xy} Vd$$

The abnormal glasses lie off the straight line so that the equation becomes

$$P_{xy} = a_{xy} + b_{xy} Vd + DP_{xy}$$

The value of DP_{xy} is a measure of the deviation of the particular partial.

As indicated above, the partial dispersion can be referred to by the relationship between the refractive index values for any particular glass at particular wavelengths referred to the line of the spectrum due to a particular material. In order to avoid difficulties due to measurement of n_f , the following expression has been used to determine value for comparison between glasses:

$$\frac{n_g - n_e}{n_f - n_c} = a_{ge} + g_{ge} V_e + DP_{ge}$$

This enables the value of D to be determined, and if negative means the particular glass being measured has a "shortened" blue partial, the more negative the value, the more extreme the glass.

We have now found that glasses with a shortened blue partial

of 50 or more.

Preferably the glass also comprises a component of Yb_2O_3 to reduce the amount of Li_2O , Na_2O or K_2O necessary.

As indicated above we measure the value of D in order to provide an indication of the shortened blue partial dispersion.

The table below demonstrates the wide range of glasses which can be made with shortened blue partials and used to form lenses for use in the optical systems of the present invention. The compositions are given in weight%;

NO ==	ZrO ₂ =====	SiO ₂ =====	Li ₂ O =====	Na ₂ O =====	B ₂ O ₃ =====	Al ₂ O ₃ =====	PbO =====	Sb ₂ O ₃ =====	Others =====	N _e =====	V _a =====	D =====
18	18.00	65.00	.00	8.50	.00	.00	.00	.00	K ₂ O 8.50	1.553	53.38	-87
19	20.42	69.69	9.90	.00	.00	.00	.00	.00		1.582	53.44	-87
20	15.73	49.85	.00	15.82	.00	.00	.00	18.60		1.615	41.34	-86
21	23.15	63.01	6.08	7.76	.00	.00	.00	.00		1.589	53.35	-85
22	12.80	50.00	3.20	.00	.00	.00	.00	.00	CaO 34.00	1.651	51.66	-84
23	15.75	71.04	4.30	8.91	.00	.00	.00	.00		1.553	54.79	-84
25	10.00	60.50	4.50	14.50	4.00	2.00	.00	.00	TiO ₂ 4.50	1.574	49.53	-82
26	18.32	58.07	.00	13.43	5.18	.00	.00	.00		1.569	52.20	-81
27	18.00	60.00	4.50	13.50	4.00	.00	.00	.00		1.576	52.87	-81
28	18.00	43.50	.00	15.70	7.50	.00	15.10	.00		1.617	43.82	-81
29	5.71	55.59	12.26	5.75	16.13	.00	.00	.00	CaO .87 TiO ₂ 3.70	1.583	53.17	-80
30	17.40	40.86	.00	15.62	10.00	.00	15.52	.50		1.619	43.71	-79
31	17.51	41.11	.00	15.71	10.06	.00	15.61	.00		1.618	43.98	-79
32	18.40	54.50	4.60	4.00	.00	.00	18.50	.00		1.624	44.55	-75
33	19.05	59.84	4.62	9.58	.00	.00	.00	.00	TiO ₂ 6.91	1.616	44.23	-73
34	18.46	45.99	.00	15.67	5.03	.00	14.72	.10		1.613	44.12	-73
35	18.45	62.99	.00	18.56	.00	.00	.00	.00		1.559	51.76	-71
36	17.51	40.00	.00	15.71	10.16	1.11	15.30	.00		1.616	44.00	-71

NO ==	ZrO ₂ =====	SiO ₂ =====	Li ₂ O =====	Na ₂ O =====	B ₂ O ₃ =====	Al ₂ O ₃ =====	PbO =====	Sb ₂ O ₃ =====	Others =====	N _c ==	V _c ==	D =
54	7.96	58.26	5.79	6.01	14.63	4.12	.00	.00	TiO ₂ 3.23	1.561	53.28	-58
55	7.96	58.86	5.79	6.01	14.63	4.12	.00	.00	TiO ₂ 2.63	1.557	54.31	-57
56	17.50	42.50	.00	15.70	9.00	.00	15.30	.00		1.616	44.13	-57
57	21.33	56.52	11.49	.00	.00	.00	.00	.00	TiO ₂ 10.66	1.665	40.32	-57
58	20.00	53.00	5.00	12.00	.00	.00	.00	.00	TiO ₂ 10.00	1.643	40.26	-55
59	17.29	45.98	6.48	.00	5.33	.00	.00	.00	La ₂ O ₃ 24.93	1.656	50.62	-55
60	18.00	65.90	4.50	7.60	4.00	.00	.00	.00		1.568	54.31	-54
61	18.00	60.00	4.50	4.00	.00	.00	.00	.00	CaO 7.50	1.602	52.73	-54
62	18.79	52.65	6.67	.00	2.00	1.00	18.89	.00		1.633	44.57	-54
63	13.67	62.74	5.25	7.88	7.32	2.06	.00	.00	TiO ₂ 1.10	1.566	54.65	-53
64	10.52	32.89	2.63	.00	.00	.00	.00	.00	BaO 53.96	1.683	49.36	-52
65	14.00	69.00	5.00	12.00	.00	.00	.00	.00		1.553	54.43	-51
66	14.00	60.50	4.50	14.50	4.00	2.00	.00	.00	TiO ₂ .50	1.565	53.55	-50
67	7.11	52.01	.00	16.09	13.06	3.68	8.05	.00		1.554	53.41	-50
68	16.00	60.00	4.00	4.00	.00	.00	.00	.00	CaO 13.00 MgO 3.00	1.604	53.10	-49
69	17.40	40.86	.00	15.62	10.00	.00	15.52	.50		1.619	43.88	-47
70	18.00	60.00	4.50	7.50	5.00	.00	.00	.00	K ₂ O 5.00	1.574	53.67	-43
71	12.00	59.00	7.00	12.00	.00	.00	.00	.00	TiO ₂ 10.00	1.614	43.02	-41

CLAIMS.

1. An achromatic lens system comprising at least two glass lenses, one lens being made of a first glass chosen to have the property known as a shortened blue partial (as hereinbefore defined), a refractive index not greater than 1.70, and a V_e number less than 55, the glass comprising at least the following components: SiO_2 , R_2O and ZrO_2 where R_2O is chosen from Li_2O , Na_2O and K_2O , the said components together forming at least 30% by weight of the glass (the balance consisting of compatible components), and the other lens is made from a second glass with a V number of 50 or more.
2. An achromatic lens system according to claim 1, wherein R_2O is chosen from Li_2O and Na_2O .
3. An achromatic lens system, wherein the first glass also comprises Yb_2O_3 .
4. An achromatic lens system according to claim 1 and incorporating a glass having a composition as set out in the foregoing Table.

